

# BMJ Open Obstetrical brachial plexus injury (OBPI): Canada's national clinical practice guideline

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## ABSTRACT

**Objective:** The objective of this study was to establish an evidence-based clinical practice guideline for the primary management of obstetrical brachial plexus injury (OBPI). This clinical practice guideline addresses 4 existing gaps: (1) historic poor use of evidence, (2) timing of referral to multidisciplinary care, (3) Indications and timing of operative nerve repair and (4) distribution of expertise.

**Setting:** The guideline is intended for all healthcare providers treating infants and children, and all specialists treating upper extremity injuries.

**Participants:** The evidence interpretation and recommendation consensus team (Canadian OBPI Working Group) was composed of clinicians representing each of Canada's 10 multidisciplinary centres.

**Outcome measures:** An electronic modified Delphi approach was used for consensus, with agreement criteria defined a priori. Quality indicators for referral to a multidisciplinary centre were established by consensus. An original meta-analysis of primary nerve repair and review of Canadian epidemiology and burden were previously completed.

**Results:** 7 recommendations address clinical gaps and guide identification, referral, treatment and outcome assessment: (1) physically examine for OBPI in newborns with arm asymmetry or risk factors; (2) refer newborns with OBPI to a multidisciplinary centre by 1 month; (3) provide pregnancy/birth history and physical examination findings at birth; (4) multidisciplinary centres should include a therapist and peripheral nerve surgeon experienced with OBPI; (5) physical therapy should be advised by a multidisciplinary team; (6) microsurgical nerve repair is indicated in root avulsion and other OBPI meeting centre operative criteria; (7) the common data set includes the Narakas classification, limb length, Active Movement Scale (AMS) and Brachial Plexus Outcome Measure (BPOM) 2 years after birth/surgery.

**Conclusions:** The process established a new network of opinion leaders and researchers for further guideline development and multicentre research. A structured referral form is available for primary care, including referral recommendations.

## Strengths and limitations of this study

- The methodology for the first obstetrical brachial plexus injury guideline was rigorous, following an established framework.
- Recommendations provide clinical guidance on the divergence of opinion and practice between primary care and specialists.
- A baseline for system performance and quality indicators for referral are established.
- In selecting the working group, the positional approach identified only surgeons (plastic and orthopaedic).
- The working group did not formally solicit guardian preferences.

## INTRODUCTION

The brachial plexus is a network of peripheral nerves providing innervation to the upper extremity. Obstetrical brachial plexus injury (OBPI) is an injury in newborns, thought to be sustained during labour and delivery.<sup>1</sup> Incidence is estimated to be between 1.6 and 2.6 in 1000 births,<sup>2</sup> equivalent to autism<sup>3</sup> and congenital deafness.<sup>4</sup> It is greater than for type 1 diabetes mellitus<sup>5</sup> and cystic fibrosis.<sup>6</sup> Shoulder dystocia is the main risk factor; others are related to fetal size and presence of comorbid birth trauma.<sup>7</sup> Clinical presentation immediately following delivery is consistent regardless of injury severity; newborns demonstrate unilateral flaccid paralysis of the involved upper limb.<sup>8</sup> Given the absence of an effective baseline investigation (as with other mechanisms of nerve injury),<sup>9</sup> serial examinations are required to determine severity and recovery potential.

Recovery of upper extremity function is the outcome guiding management. Most cases of OBPI are transient,<sup>10</sup> with complete spontaneous recovery expected. However, children with incomplete recovery experience lifelong functional impairment; long-term sequelae

include weakness, joint deformity and limb length discrepancy.<sup>11 12</sup> Beyond physical impairment, OBPI impacts the family dynamic<sup>13</sup> and the child's global development.<sup>11</sup>

For all injury severities, assessment<sup>14</sup> and non-operative (occupational and physical) therapy<sup>15</sup> are provided at specialised multidisciplinary centres.<sup>16–19</sup> For infants with residual deficits, numerous operative algorithms,<sup>14 20–24</sup> repair techniques<sup>25–33</sup> and evaluation methods<sup>34</sup> are available. Authors have expressed the need for guidelines for OBPI management<sup>35 36</sup> addressing clinical gaps.

### Gap 1: historic poor use of evidence

Residual deficits with non-operative therapy are underestimated,<sup>10 37</sup> and surgical outcomes are evaluated inconsistently.<sup>30</sup> Nerve repair has not been analysed with a high-quality study,<sup>38</sup> despite acknowledgment of its need.<sup>39 40</sup> The existing literature is not optimised; no synthesis has addressed existing cohort studies of nerve repair versus non-operative therapy.

### Gap 2: timing of referral to multidisciplinary care

While a proportion of injuries spontaneously recover,<sup>10</sup> they are not discernible at baseline from those that require repair.<sup>41</sup> Primary care providers may overestimate recovery, causing guardian distress and delayed multidisciplinary referral. Ideal referral timing is not established. Early referral to a multidisciplinary centre is important; it allows guardian education,<sup>42</sup> treatment by specialised therapists,<sup>12 14</sup> and serial assessment for recovery and operative planning if necessary.<sup>41</sup> Peripheral nerve injuries require timely repair. The optimal age for nerve repair is 3 months for the most severe injuries.<sup>14</sup> However, up to 12% of referrals to multidisciplinary clinics are 3 years or older with long-standing functional impairment.<sup>24</sup>

### Gap 3: indications and timing of operative nerve repair

Mild injuries with significant recovery by 1 month do not require repair.<sup>24</sup> Total plexus injuries require early repair to preserve function.<sup>14 24</sup> However, 50–90% of referrals to specialty centres have injuries between these extremes, with surgical indications and timing varying between centres.<sup>21 22 43–45</sup>

### Gap 4: distribution of expertise in Canada

OBPI expertise is not evenly distributed across the country, with 10 multidisciplinary centres in Canada located at academic institutions in large cities. Unified recommendations from OBPI specialists do not exist to guide practice or inform the public.

There is a clear opportunity to improve the quality of OBPI care,<sup>46</sup> and the clinical conditions are appropriate for guideline development.<sup>47</sup> A rigorous review of current literature<sup>47 48</sup> would address an evidence base insufficient to support decisions of clinicians.<sup>46</sup> Improving the knowledge and intent of behaviours<sup>49</sup> would minimise unwanted practice variation, as well as

the divergence of opinion between primary care and OBPI specialists. A consistent national message would inform guardians.<sup>47 50</sup> Establishing quality indicators would inform policy, access to care and funding.<sup>51</sup> Ultimately, implementation would result in improved outcomes.<sup>52</sup> The process of guideline development itself can also foster collaboration and cohesion among national specialists,<sup>49</sup> providing a platform for a national research programme.<sup>51</sup> Currently, no comprehensive guideline exists in Canada, or elsewhere, to guide the management of OBPI.

This guideline examines the evidence for: (1) *primary management of OBPI*, including treatment with nerve repair and physical/occupational therapy, (2) *timing of referral to a multidisciplinary centre* and (3) *standardised outcome measurement*. Intended users are those delivering care to infants in the first year of life, and peripheral nerve surgeons, therapists and other specialists treating OBPI impairment.

## METHODS

The development of guideline recommendations followed Cancer Care Ontario's Program in Evidence-Based Care framework, the Guideline Development Cycle.<sup>46 53</sup>

## Governance

A small group consisting of a plastic surgeon with expertise in management of OBPI (JRB), a health services researcher with expertise in the science and practice of clinical practice guidelines (MCB), and a trainee in both plastic surgery and health research methodology (CJC) provided oversight to the project. Recruitment for the OBPI Working Group<sup>49</sup> followed a positional approach.<sup>54</sup> Lead physicians at each Canadian OBPI multidisciplinary centre of excellence were invited to be members of this team. Twelve physicians agreed to participate in guideline development, with representation from every Canadian multidisciplinary centre (table 1).

**Table 1** Members of the working group participating in the consensus process

Consensus group members	Institution
Dr James Bain	McMaster University
Dr Michael Bezuahly	Dalhousie University
Dr Sean Bristol	University of British Columbia
Dr Howard Clarke	University of Toronto
Dr Robertson Harrop	University of Calgary
Dr Jennifer Lin	Universite de Montreal
Dr Jaret Olson	University of Alberta
Dr Douglas Ross	Western University
Dr Constantin Stanciu	Universite de Montreal
Dr Susan Thompson	University of Manitoba
Dr Cynthia Verchere	University of British Columbia
Dr Yvonne Ying	University of Ottawa

This established the Canadian OBPI Working Group. The group's tasks included: providing feedback on the systematic review of primary management, approving quality indicators for referral timing analysis, collecting and providing volume and timing of referrals at their centres, participating in the formal consensus process to craft, refine and agree on recommendations for the clinical practice guideline, and establishing a common data set for future OBPI research.

Recommendations were developed through two in-person meetings, and electronic correspondence from June 2013 to June 2015. The guideline was further reviewed for methodology (AT, SHV), and clinical sensibility to plastic surgery (AT, SHV) and obstetrics and gynaecology (MKC).

### Recommendation development

The working group generated a preliminary topic list reflecting opportunities for quality improvement,<sup>55 56</sup> and assigned evidence to each topic (box 1). For primary management (nerve repair, physical/occupational therapy), functional impairment was considered the primary outcome; pooled adverse events were the secondary outcome. For referral to a multidisciplinary centre, the working group identified importance of conservative timing among guardians.<sup>36 42 57</sup> The consensus group concurred early referral was favoured, in order to maximise education and therapy, and capture patients for operative planning. Outcome measures addressed each domain of the WHO's International Classification of Function, Disability and Health (ICF).<sup>58</sup> Quality of evidence, bias and uncertainty were considered in all outcomes.<sup>59</sup> Recommendations were based on best available evidence and focused exclusively on the clinical perspective. While implementation will ultimately necessitate consideration of resources, this will be tailored to each jurisdiction.<sup>59</sup>

### Sources of evidence

#### Identification of existing guidelines

Recognised databases were searched for existing clinical practice guidelines. OBPI is referred to by many terms,<sup>60</sup> with specific variation in the leading (eg, neonatal or paediatric instead of obstetrical) and end (eg, palsy

instead of injury) terms. For sensitivity, only the term 'brachial plexus' was used in searches.

#### Systematic review and meta-analysis of primary management

A new systematic review and meta-analysis was designed investigating the effect of primary nerve repair versus non-operative management on physical function.<sup>2</sup>

#### Review of Canadian epidemiology and burden of disease

A new analysis of Canadian epidemiology and burden was designed establishing quality indicators for referral, and investigating volume and timing of referral to multi-disciplinary centres, incidence and risk factors.<sup>61</sup>

#### Systematic review of outcome assessment

To inform the selection of outcome measures for multi-centre research, a focused search for systematic reviews investigating OBPI outcome measures was performed. Records meeting each of the following criteria were included: systematic review, published in peer-reviewed journals as full reports, reviewed outcome measures, included patients with OBPI, English language and published since 2009.

The same electronic search strategy from the systematic review and meta-analysis was used<sup>2</sup> and executed on 15 February 2014: Ovid MEDLINE(R) In-Process and Other Non-Indexed Citations and Ovid MEDLINE(R) 2009 to present, Ovid MEDLINE Daily Update 15 February 2014, EMBASE 2009 to 2014 week 6 and reviews in the Cochrane Library 2014, issue 1 (list 1). Quality assessment was performed using the AMSTAR tool.<sup>62</sup>

#### Environmental scan

A search was performed to provide an estimate of referral processes in other jurisdictions, and inform recommendations.<sup>46</sup> Relevant professional organisations were searched for applicable documents (as in *identification of existing guidelines*). An untargeted web search was completed on 1 November 2012 and updated on 15 February 2014. The following terms were queried: 'brachial plexus', referral and guidelines.

Multidisciplinary clinic websites were reviewed for the referral process from primary care, timing and specific criteria.

#### Formal consensus

A formal consensus process was selected.<sup>46 63</sup> All members participated in consensus to improve ownership and consistency in national recommendations.<sup>47 63</sup> An electronic modified Delphi approach<sup>64</sup> was selected for its transparent, explicit and structured methodology.<sup>46 65 66</sup> Recommendations and key evidence summaries were distributed to the consensus group.

Members rated agreement for each recommendation using a nine-point Likert scale (1='strongly disagree', 9='strongly agree'),<sup>67</sup> and had the ability to provide

#### Box 1 Preliminary topic list to be addressed by recommendations

- ▶ Recommendation topics;
- ▶ Identification of obstetrical brachial plexus injury by primary care;
- ▶ Timing of referral to a multidisciplinary centre;
- ▶ Information to communicate between primary care (diagnosis), multidisciplinary care (specialised therapy) and primary care (follow-up);
- ▶ Personnel at multidisciplinary centres;
- ▶ Timing of operative therapy;
- ▶ Common data set elements for national multicentre research.

written feedback. Thresholds for consensus to 'support' or 'reject' recommendations were conservative and defined a priori.<sup>67</sup> Consensus was defined based on a group size of 12.<sup>67</sup> A median of 7–9 with 3 or fewer ratings outside of the 7–9 range was defined as consensus to support the recommendation. A median of 1–3 and 3 or fewer ratings outside of the 1–3 range was defined as consensus to reject the recommendation. Further, four or more members rating in the 1–3 and 7–9 ranges were defined as consensus to reject the recommendation. Other combinations were defined as uncertain, indicating the need for modification.

Qualifying statements were added to recommendations based on consensus group feedback. This allowed for the necessary clarification and contextualisation to be provided even in cases when consensus was obtained according to the a priori criteria.

## Review

No external review process was specified a priori. Recommendations were established by a formal consensus process including national key stakeholders and clinical experts. The guideline was reviewed for completeness of literature review<sup>68</sup> (AT, SHV), clinical sensibility<sup>68</sup> to plastic surgery (AT, SHV) and obstetrics and gynaecology (MKC), and by an expert in systematic review and guideline development (MCB).<sup>68</sup> Further external review was not appropriate and would be redundant.<sup>46</sup> Education of primary care was a goal of the guideline; in cases where there is disagreement between specialists and primary care, and referrals need to be increased, review by primary care may be detrimental.<sup>69</sup>

## RESULTS

### Sources of evidence

#### Identification of existing guidelines

No existing guideline or set of recommendations adequately addressed the objectives of the working group, or used an optimised synthesis of the OBPI literature.

### Systematic review and meta-analysis of primary management

A systematic review and meta-analysis was completed investigating the effect of primary nerve repair versus non-operative management on physical function.<sup>2</sup>

### Review of Canadian epidemiology and burden of disease

An analysis of Canadian epidemiology and burden was completed establishing quality indicators for referral, and investigating volume and timing of referral to multi-disciplinary centres, incidence and risk factors.<sup>61</sup>

### Systematic review of outcome assessment

A focused search for systematic reviews of outcome assessment was performed, identifying three reviews.<sup>34 70 71</sup> Full results are reported in online supplementary appendix 1.

### Environmental scan

The environmental scan identified seven documents advising referral for identified OBPI to specialty care.<sup>72–78</sup> Full results are reported in online supplementary appendix 1.

### Recommendations

Seven recommendations were developed addressing the topic list. The consensus group supported all recommendations in the first round of review (table 2). The evidence was judged to be universally low for all recommendations. Recommendations and qualifying statements were distributed to the consensus group; no member disapproved or provided additional feedback.

- 1. Physically examine newborns for OBPI if upper extremity movement is asymmetric or delivery was complicated by shoulder dystocia, humeral fracture or clavicular fracture.**

*A primary care physician with experience in newborn assessment should perform a focused physical examination on newborns with an identified deficit or risk factor.*

**Table 2** Results of the consensus process for recommendations

Recommendation	Responses (n=12)									Median	Feedback
	1	2	3	4	5	6	7	8	9		
1					1			1	10	9	Not all children are born in a hospital, and/or with physicians present, primary care to examine as a gatekeeper for referral
2							2	2	8	9	Small proportion of cases recover before discharge
3			1				5		6	8	Clinical records are important and useful but not necessary
4 i							1	2	9	9	Provide definition of therapist
4 ii								1	11	9	Provide definition of surgeon
5							5	2	5	8	Communication and/or follow-up
6 i								4	8	9	Clarify total plexus +T1 avulsion
6 ii							2	3	7	9	None
7 i			1				7	1	3	7	Root levels, an alternative to formal Narakas
7 ii			1				4	2	5	8	Outcomes are not a substitute for operative indications; limb length to nearest 0.5 cm as in original report

Green = support; red = reject; yellow = uncertain.

- ▶ From the analysis of Canadian epidemiology, incidence is 1.24/1000 live births, and consistent from 2004 to 2012, with all potential biases underestimating incidence.<sup>61</sup> From the meta-analysis of primary management, pooled incidence in demographic samples was 2.1/1000 births (95% CI 1.6 to 2.6).<sup>2</sup>
- ▶ From the analysis of Canadian epidemiology, very strong risk factors were 'birth injury to humerus' OR=115.0 (95% CI 86.7 to 152.5), 'shoulder dystocia' OR=59.8 (95% CI 55.5 to 64.5) and 'fracture of clavicle' OR=31.0 (95% CI 26.4 to 36.4).<sup>61</sup>
- ▶ In Canada, referrals to specialty physicians (ie, OBPI centres) are generated by other physicians. A primary care physician with experience in newborn assessment should examine children with asymmetric upper extremity movements to detect OBPI, comorbidities and possible alternate diagnosis for appropriate management, including referral.

## 2. Refer all newborns with OBPI to a multidisciplinary centre by 1 month of age.

*A proportion of newborns will completely recover within days of birth and do not necessitate referral to a multidisciplinary centre. Newborns with complete recovery as assessed by primary care providers experienced in the assessment of musculoskeletal and neurological deficits do not necessitate referral.*

- ▶ The selection of 1 month was informed by the environmental scan, practice patterns,<sup>14 24</sup> Malessy *et al*'s<sup>41</sup> referral algorithm and the previous Canadian position statement.<sup>79</sup>
- ▶ The consensus group formally approved quality indicators for infant age at initial assessment by a multidisciplinary centre; 'good' by 1 month of age, 'satisfactory' by 3 months of age and 'poor' thereafter.<sup>61</sup>
- ▶ Early referral to a multidisciplinary centre permits guardian education,<sup>42</sup> early treatment by specialised therapists,<sup>12 14</sup> serial assessment for recovery and appropriate operative assessment.<sup>41</sup>
- ▶ Guardians prefer early referral to a multidisciplinary centre.<sup>36 42 57</sup>
- ▶ Neuropraxic injuries recover rapidly, and infants are substantially to completely recovered by 1 month.<sup>14 21 24 79</sup> From the meta-analysis of primary management, this proportion is 35% of patients (95% CI 23% to 48%).<sup>2</sup>
- ▶ Primary care providers may underestimate residual impairment in OBPI. From the meta-analysis of primary management, non-operative management of OBPI in demographic populations results in functional impairment in 18% (95% CI 14% to 23%). Only three reports assess outcomes with physical scales; the remainder rely on subjective assessment. This reflects traditional reports of OBPI from primary care, reporting transient injury without sequelae.<sup>17 80 81</sup> In contrast, full recovery occurs in 73% (95% CI 64% to 81%) of patients from demographic samples. 'Full recovery' itself is most likely

overestimated.<sup>10</sup> Interpreted inversely, the author-defined incidence of any residual impairment is 27% (19% to 36%). This proportion demonstrates that at least 19% to 36% of OBPI cases have an uncharacterised, unidentified residual impairment.<sup>2</sup>

- ▶ A systematic review by Pondaag *et al*<sup>10</sup> agreed that OBPI prognosis is worse than that identified in the literature and predicted in practice.

## 3. With referral, provide complete pregnancy and birth history, and physical examination findings (including Horner's syndrome) at birth.

*Clinical records should indicate risk factors, severity of injury and course of recovery. While clinical records are important, they are not necessary; do not delay referral to a multidisciplinary centre to obtain records.*

- ▶ No study identified and analysed the impact of referral information or communication on outcome.
- ▶ Given the absence of a gold standard baseline investigation,<sup>9</sup> serial examination is required to determine severity. Clinical records may provide an estimate of initial severity and progression of recovery.
- ▶ Discussion of risk factors contributes to guardian education,<sup>42</sup> especially for future pregnancies.<sup>82</sup>
- ▶ Clinical root level involvement (eg, presence of hand paralysis) and Horner's syndrome are discerning characteristics in the Narakas classification<sup>83</sup> for baseline injury classification (recommendation 7).

## 4. Teams at multidisciplinary centres should include:

- i. **A dedicated therapist with experience in the assessment and treatment of OBPI.**
- ii. **A peripheral nerve surgeon with experience in microsurgical repair of OBPI.**

*Teams at multidisciplinary centres are responsible for the assessment, treatment, rehabilitation and education of children with OBPI and their parents/guardians. Teams should include the personnel necessary to deliver the highest level of treatment available in Canada. The recommendation does not pertain to healthcare providers involved in diagnostic investigations or secondary treatment. A therapist is a physical or occupational therapist, or equivalent. Ideally, the therapist will have paediatric experience and/or be mentored to develop skills to manage patients with OBPI. A peripheral nerve surgeon is a plastic, neurosurgeon or orthopaedic surgeon, or equivalent. The peripheral nerve surgeon will have the training, experience and infrastructure to perform microsurgical nerve reconstruction procedures on paediatric patients.*

- ▶ No study identified and analysed the impact of multidisciplinary teams or their included disciplines on OBPI outcomes.
- ▶ The meta-analysis of primary management pooled all non-operative management, including natural history; outcomes did not analyse specific non-operative therapy interventions or protocols. Descriptions of non-operative management protocols were poor. The only reliable factor was involvement of a therapist in

management. Among 65 studies with patients treated by specialists, the care team was multidisciplinary in 43.<sup>2</sup>

- ▶ Two previous systematic reviews<sup>84 85</sup> addressed non-operative interventions excluding natural history. Each review highlighted the importance of therapists delivering non-operative treatment,<sup>43 85</sup> and suggested that all infants be assessed by a specialised therapist,<sup>84</sup> for management and parent/guardian education.<sup>57</sup> Non-operative protocols were descriptively reviewed in these prior reviews; details of interventions were poor prohibiting replication,<sup>85</sup> and insufficient evidence exists to support specific treatment recommendations beyond therapist referral.<sup>84 85</sup>

##### 5. Non-operative therapy delivered outside of a multidisciplinary centre should be advised by a multidisciplinary team.

*No qualifying statement.*

- ▶ No study identified and analysed the impact of non-operative therapy delivered or supervised by a specialised multidisciplinary centre versus in the community.
- ▶ Community providers may not have the expertise to recognise and characterise residual impairment. Ongoing communication between multidisciplinary and community providers may identify patient issues throughout the child's growth and development, and expedite specialised assessment.

##### 6. Offer microsurgical nerve repair:

- i. For injuries clinically consistent with root avulsion injury.
- ii. For all other injuries meeting centre-defined operative criteria applied beginning at 3 months of age.

*Total plexus injuries with clinical evidence consistent with T1 root avulsion (eg, Horner's syndrome) should be offered nerve repair as soon as the injury pattern is apparent and the child is fit for the procedure.*

- ▶ From the meta-analysis of primary management, pooled analysis of 222 patients from nine cohort studies shows that nerve repair reduces impairment; relative risk (RR) 0.58, 95% CI 0.43 to 0.79,  $p < 0.001$ , absolute risk reduction (ARR) 19%, number needed to treat (NNT) 6. This outcome may underestimate the effectiveness of primary nerve repair. Results are consistent in analysis of case series, RR 0.39, 95% CI 0.33 to 0.45.<sup>2</sup>
- ▶ Avulsion injuries are the most severe; these injuries are worse than the severity represented by our pooled analysis. The nerve root is physically separated from the motor cell body within the spinal cord. No motor spontaneous recovery is expected.<sup>12</sup>
- ▶ From the meta-analysis of primary management, mortality and major adverse events are not common risks of modern microsurgical nerve repair. Adverse events were reported in 19 series of operative management in our review. No deaths were reported. Major events occurred in 1.5% of cases.<sup>2</sup>

##### 7. For objective outcome collection, a common data set includes:

- i. Clinical distribution using the Narakas classification at the initial multidisciplinary centre assessment.
- ii. Limb length,<sup>11</sup> Active Movement Scale (AMS)<sup>86</sup> and Brachial Plexus Outcome Measure (BPOM) when age applicable<sup>71</sup> at 1, 3, 6, 12 and 24 months of age, then annually for the duration of follow-up.

*The common data set provides consistent baseline stratification and outcome measurement, facilitating multicentre research. Data set outcomes are not operative indications. Alternatively to the Narakas classification, injury distribution can be classified by involved nerve roots and evidence of Horner's syndrome. For consistency, each outcome should be measured as defined in the primary literature (eg, limb length to nearest 0.5 cm).*

- ▶ For injury baseline classification, the Narakas classification<sup>83 87</sup> is the most common classification system used, though reliability and validity are not formally established, and modifications have been suggested.<sup>87</sup>
- ▶ Three systematic reviews<sup>34 70 71</sup> suggested assessing OBPI using the ICF domains. An ICF Core Set is currently lacking.<sup>88</sup>
- ▶ The AMS<sup>86</sup> is validated in OBPI with robust psychometric properties. It measures ICF Body Functions and Structure.
- ▶ The BPOM<sup>71</sup> is a disease-specific functional assessment tool with excellent construct validity. It complements the AMS. Psychometric evaluation and analysis of evaluative validity are pending. In contrast to other tools, it is practical to administer and score, and evaluates the complete upper extremity. It measures ICF Activity and Participation in the context of a child's own environment.
- ▶ Physiologically, limb length and circumference<sup>11</sup> are reliable, and discrepancies are detected as early as 1 month in severe lesions. Growth discrepancy is limited with nerve repair, and correlates with impairment.<sup>89</sup>
- ▶ Timing of outcome assessment was not discussed in reviews. In the meta-analysis of primary management, outcomes were measured until at least 2 years of age for non-operative management, or 2 years following operative management.<sup>2</sup>

## DISCUSSION

This is the first formal clinical practice guideline for the primary management of OBPI. In situations where practice is heterogeneous and evidence is unclear, rigorous approaches to knowledge synthesis and application have the greatest capacity to impact practice.<sup>49</sup>

### Context

Early referral is guardian important, it provides early coordinated assessment and education at multidisciplinary centres. Recommendations 1–3 address primary care awareness of OBPI, and inform referral. The 1 month

time point is conservative, reflecting guardian, physician and therapist preference. The proportion of neuropraxic injuries will recover substantially within 1 month. However, the consensus group reflected each centre's preference to assess all infants identified with OBPI. While a novel algorithm endorses early identification and referral of only potential surgical candidates,<sup>41</sup> it relies on interpretation of electromyography and nerve conduction study. It is feasible that a referral system could be overseen by multidisciplinary centres to interpret history and investigations completed at satellite centres; timing of consultation with physicians and therapists could then be triaged appropriately. This could address geographic distribution of specialists in Canada.

Recommendations 4–6 reflect the personnel and management to provide evidence-based care. Evidence is insufficient to recommend specific non-operative interventions or therapy protocols. While functional impairment with nerve repair reduces functional impairment versus non-operative management, recommendations do not differentiate OBPI severity beyond avulsion, or identify the best surgical algorithm and/or nerve repair procedure. While the evidence did not support one surgical algorithm, it is sufficient to support the principle of early nerve repair in patients failing to recover. Further evidence is required to guide specifics of non-operative and operative protocols.

Multicentre study is required to achieve sufficient sample size to inform specific therapy recommendations, given the range of OBPI clinical patterns and nerve repair options available. In its design, this guideline has formed a network of opinion leaders with representation from every multidisciplinary centre. An engaged network and consistent outcome assessment will facilitate evaluation of the interventions and algorithms already practised at Canadian centres.<sup>24 32 43 90 91</sup>

### Strengths

Our methodology was rigorous, following an established framework.<sup>46</sup> Guideline implementation and dissemination were considered in design;<sup>49</sup> opinion leaders were chosen for their influence on local health policy and resources.<sup>92</sup> The formal consensus process<sup>64</sup> was transparent and structured;<sup>46 65 66</sup> it accommodated the geographic distribution of the consensus group,<sup>93</sup> and anonymity prevented the process from being dominated.<sup>94</sup> Two original studies were performed to optimise the evidence base, and clear connections were established between the evidence base and recommendations. The recommendations themselves addressed broad, system-level questions; they provide clinical guidance on the divergence of opinion between primary care and specialists. A baseline for system performance is established with quality indicators for referral.

### Limitations

In selecting the OBPI Working Group, the positional approach identified only surgeons. Future updates to this

guideline will be multidisciplinary. The guideline was reviewed by experts for completeness of literature review, clinical sensibility and methodology;<sup>68</sup> further external review would be redundant.<sup>46</sup> Further, education of primary care and addressing disagreement between specialists and primary care were goals of the guideline.<sup>69</sup> An estimation of cost was not available. The working group did not formally solicit guardian preferences; recommendations relied on patient preferences for referral, education and management from the literature.<sup>36 41 42 95</sup> The GRADE approach was not used, reflecting many cancer guideline bodies.<sup>96</sup> OBPI is similar to cancer given its small expert pool, treatment at specialised academic centres, and absence of level I evidence. GRADE has a number of limitations in this clinical setting.<sup>96</sup> Instead, we followed an established framework,<sup>46</sup> interpreted strength of evidence in every facet of the evidence base and used a formal consensus process.

### Implementation

With establishment and baseline measurement of quality indicators for referral, an optimised meta-analysis for nerve repair and a clinical practice guideline, this programme of research provides the tools and means to improve quality of care, health services, patient outcomes and policy for OBPI in Canada. However, without an approach to implementation, recommendations often fail to achieve potential benefits in care process, use of best evidence and practice consistency.<sup>52 97 98</sup> There is insufficient evidence to support one guideline implementation strategy, or a cluster of strategies.<sup>99</sup> However, integrated knowledge translation (IKT) interventions are suited to OBPI. IKT integrates relevant end users and researchers in intervention design and dissemination.<sup>98</sup> IKT is particularly relevant to OBPI given the range of providers involved in perinatal care and the multidisciplinary team involved in management.<sup>98</sup> Collaboration between primary care, parents, specialists and resource managers is critical to timely referral and optimised care.

### CONCLUSIONS

#### The Canadian OBPI Working Group: next steps

Referral to multidisciplinary care is a gap in OBPI care. Referral recommendations are more effective if local specialists are involved in dissemination, and structured referral forms are available.<sup>100</sup> The Canadian OBPI Working Group already includes leaders at each national multidisciplinary centre. To improve referral, and provide consistent information to primary care and guardians, the working group has developed a national referral form (see online supplementary appendix 2).

A multidisciplinary guideline can integrate a fragmented patient management system and enhance implementation. Only a multidisciplinary group can connect public education and awareness, risk factor modification, referral, assessment and therapy. The planned update to

this guideline includes all relevant primary care and specialty disciplines: therapists, primary care, obstetrics, perinatal care and child specialists. An introductory multidisciplinary meeting occurred in June 2015.

Guideline development formed a network of opinion leaders, and recommendations included outcome assessment to establish a common data set. The working group is endeavouring to establish a shared database for novel research, and multicentre studies. Active national research will improve access to evidence-based therapies and measure outcomes across our healthcare system.

Overall, the Canadian OBPI Working Group's goal is to transform OBPI care with a model that recognises patient priorities from labour/delivery to full maturity, while achieving best care at every level of the healthcare system. Resources are available, and our activities can be followed at [brachialplexus.ca](http://brachialplexus.ca).

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